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Enghoff, Henrik

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Research article

Three new species of *Dolichoiulus* millipedes from the underground of Gran Canaria, with notes on the circumscription of the genus (Diplopoda, Julida, Julidae)

Henrik ENGHOFF

Natural History Museum of Denmark, University of Copenhagen,
Universitetsparken 15, DK-2100 Copenhagen OE, Denmark.

Email: henghoff@snm.ku.dk

Abstract. *Dolichoiulus typhlocanaria* sp. nov., *D. oromii* sp. nov. and *D. longunguis* sp. nov. are described from caves and the mesovoid shallow stratum (MSS) on Gran Canaria. The genus *Anagaiulus* Enghoff, 1992 is synonymized under *Dolichoiulus* Verhoeff, 1900, resulting in *Dolichoiulus blancatypa* (Enghoff, 1992) comb nov.

Key words. Millipede, Canary Islands, new species, cave, Gran Canaria.

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Introduction

The millipede genus *Dolichoiulus* Verhoeff, 1900 includes one of the largest among the many radiations of plants and animals on the Canary Islands (Fernández-Palacios 2011). Of the 56 species hitherto included in the genus, 46 are Canarian endemics (Enghoff 1992, 2011; Enghoff & Báez 1993). Enghoff (1992) revised the genus and described 39 new species. Despite considerable collecting activity on the Canary Islands since 1992, no additional new species have been discovered until now.

Five Canarian *Dolichoiulus* species have been found in caves, three endemic species on Tenerife, one endemic species on El Hierro and the introduced *D. typhlops* Ceuca, 1973 on La Palma and El Hierro (Enghoff 1992, 2002). The three Teneriffan cave species are blind, like the introduced *D. typhlops*. In recent years, blind *Dolichoiulus* millipedes have been collected in several caves and MSS (mesovoid shallow stratum, Romero 2009) on Gran Canaria. This material includes three new species and is the subject of the present paper. One of the new species shows a character that necessitates a re-evaluation of the genus *Anagaiulus* Enghoff, 1992, a monotypic genus from Tenerife.

Material and methods

Specimens were collected in MSS with special pitfall traps designed for collecting in this habitat (see López & Oromí 2010), whereas those captured in caves and mines which were found by visual exploration. All were preserved in 70% ethanol and were examined with a stereomicroscope. A few

specimens were ‘analysed’, i.e., gnathochilarium, an antenna, and some midbody legs were temporarily mounted in glycerol and examined at high magnification in a compound microscope. Gonopods/vulvae of some specimens were similarly placed in temporary mounts. Specimens for scanning electron microscopy were transferred to 96% ethanol and then to acetone, air-dried, mounted on aluminium stubs, coated with platinum/palladium and studied in a JEOL JSM-6335F scanning electron microscope (ZMUC).

Terminology follows Enghoff (1992) except that the term ‘ring’ or ‘body ring’ is used instead of ‘segment’, and ‘mesomerital process’ instead of ‘mesomerite’.

Abbreviations used in the text

DZUL	= Department of Animal Biology (Zoology), University of La Laguna, Tenerife, Canary Islands
GE	= Grupo de Espeleología
H	= height (vertical diameter) of body
L	= length of body
MCNT	= Museum of Natural Sciences of Tenerife, Canary Islands
MELANSIS	= Sociedad Entomológica Canaria Melansis, Gran Canaria, Canary Islands
MSS	= mesocavernous shallow stratum, or milieu souterrain superficiel
ZMUC	= Natural History Museum of Denmark (Zoological Museum), University of Copenhagen
GIET	= Grupo de Investigaciones Espeleológico de Tenerife

Results

Class Diplopoda Blainville-Gervais, 1844
Order Julida Leach, 1814
Family Julidae Leach, 1814
Genus *Dolichoiulus* Verhoeff, 1900

Dolichoiulus Verhoeff, 1900: 85.

Nesopachyiulus Attems, 1902: 599, 607.

Trichopachyiulus Verhoeff, 1910: 194.

Anagaiulus Enghoff, 1992: 144 **syn. nov.**

See Enghoff (1992) for an in-depth discussion of *Dolichoiulus*. *Anagaiulus* was erected by Enghoff (1992) for a species which differs from the *Dolichoiulus* species in having a whorl of metazonital setae. Enghoff (1992) realized that this is a poor diagnostic character but preferred not to ‘dilute’ the already rather vague concept of *Dolichoiulus* by including a species with metazonital setae. Since then, two lines of evidence have emerged that contradict separate status for *Anagaiulus*:

1. One of the new species described in the present paper has metazonital setae; the other doesn’t, but apart from this, and a size difference, the two species are as good as identical.
2. A preliminary molecular phylogenetic analysis by I. Sanmartín (unpublished) suggests that *Anagaiulus* is nested deeply inside *Dolichoiulus*.

Diagnosis

(from Enghoff 1992, emended): Pachyiulini. Eyes present or absent. No frontal setae. Mostly without metazonital setae (exceptions: *D. blancatypa* (Enghoff, 1992) comb. nov. and *D. oromii* sp. nov.). Metazonital striae mostly distinct also dorsally. No grooves in suture. No (or almost no) preanal projection. Preanal pilosity marginal or extensive. Anal valve pilosity extensive. Male mandibles mostly without lobes. First and second male legs typically julid. Male legs mostly with ventral pads. Anterior

gonopod spoon-shaped, with a mesal ridge, a lateral prominence, and two apical denticles (which may be fused or reduced). Posterior gonopod without a sperm fovea, with a mesomerital process and with two opisthomerital processes, posterior process varying from short-triangular to flagelliform; one or both opisthomerital processes sometimes more or less reduced.

Included species

Dolichoiulus blancatypa (Enghoff, 1992), comb. nov. ex *Anagaiulus*, *D. typhlocanaria* sp. nov., *D. oromii* sp. nov., *D. longunguis* sp. nov., plus the 56 species included in Enghoff (1992).

Dolichoiulus typhlocanaria sp. nov.

Figs 1, 2A, 3A, B, 4A, B

Diagnosis

A blind species of *Dolichoiulus*. Differs from other blind *Dolichoiulus* species as shown in Table 1. Differs from the other blind *Dolichoiulus* on Gran Canaria in size (Figs 1, 5). Differs from *D. oromii* sp. nov. in lacking metazonital setae, in having only marginal preanal pilosity, and in having a terminal projection on the mesal ridge of the anterior gonopod. Differs from *D. longunguis* sp. nov. and the widespread *D. typhlops* in having clearly slenderer anterior gonopods (Fig. 3A, B, cf. Fig. 3D).

Etymology

The name (noun in apposition) refers to the blindness of this species from Gran Canaria.

Type locality

GRAN CANARIA (Canary Islands), Barranco del Draguillo.

Material examined (all from Canary Islands: Gran Canaria)

Holotype

♂, Barranco del Draguillo, UTM 28R 4561/30913 (27°56'45"N, 15°26'45"W), MSS, 26 Dec. 2006, H. López leg. (DZUL).

Paratypes

3 ♂♂, 2 ♀♀, same locality, 16 Aug. 2007, H. López leg. (1 ♂, 1 ♀ DZUL; 2 ♂, 1 ♀ ZMUC); 3 ♂♂, 2 ♀♀, same locality, 26 Dec. 2010, H. López leg. (ZMUC); 9 ♂♂, 6 ♀♀, same locality, 30 Dec. 2011, H. López leg. (DZUL).

Referred (non-type) material

2 ♂♂, 1 ♀, Cueva de la Luna, UTM 28R 4478/30873 (27°54'36"N, 15°31'48"W), 23 Dec. 2006, GIET leg. (ZMUC); 2 ♂♂ Cueva de los Arrepentidos, UTM 28R 4482/30878 (27°54'51"N, 15°31'35"W), 26 Dec. 2006, GIET leg. (DZUL); 1 ♂, 2 ♀♀, Los Majateles, UTM 28R 4505/30915 (27°56'08"N, 15°30'10"W), MSS, 26 Dec. 2010, H. López leg. (DZUL).

Total material

21 ♂♂, 13 ♀♀ (1 ♂, 1 ♀ analyzed).

Description

♂: L 14-20 mm, H 1.03-1.26 mm, L/H 13-16, 33-52 podous rings + 1-2(3?) apodous rings in front of telson.

♀: L 15-20 mm, H 1.17-1.41 mm, L/H 12-16, 36-52 podous rings + 2 apodous rings in front of telson.

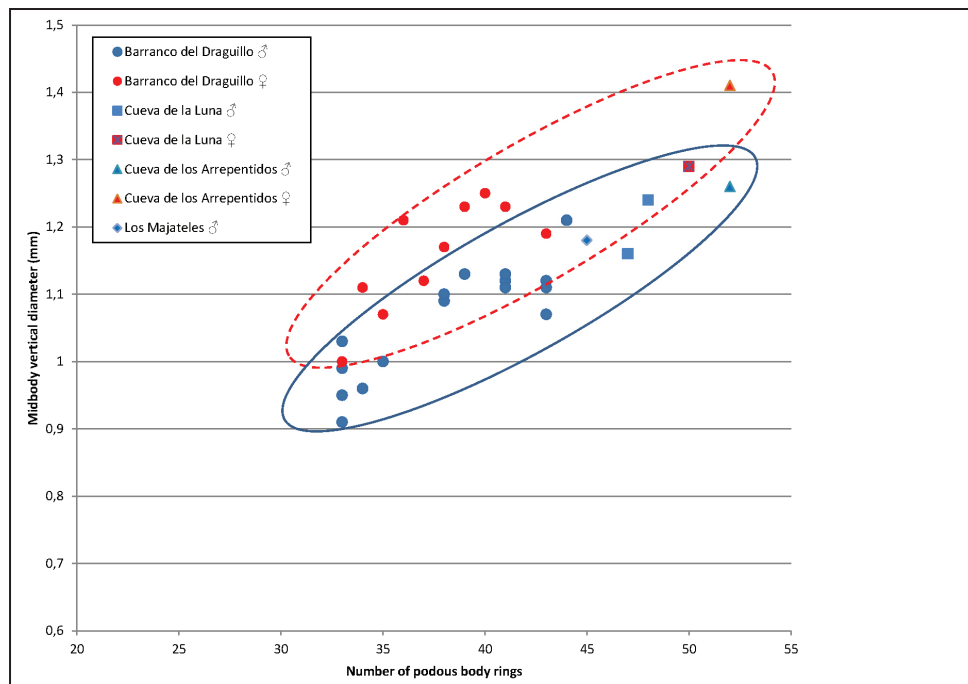


Fig. 1. Size diagram for *Dolichoiiulus typhlocanaria* sp. nov. The diagram shows number of podous (leg-bearing) body rings (p.r., x axis) and vertical body diameter in mm (y axis). For a given number of podous rings *D. typhlocanaria* sp. nov. is thicker than the two other species (see Fig. 5), and females are thicker than males.

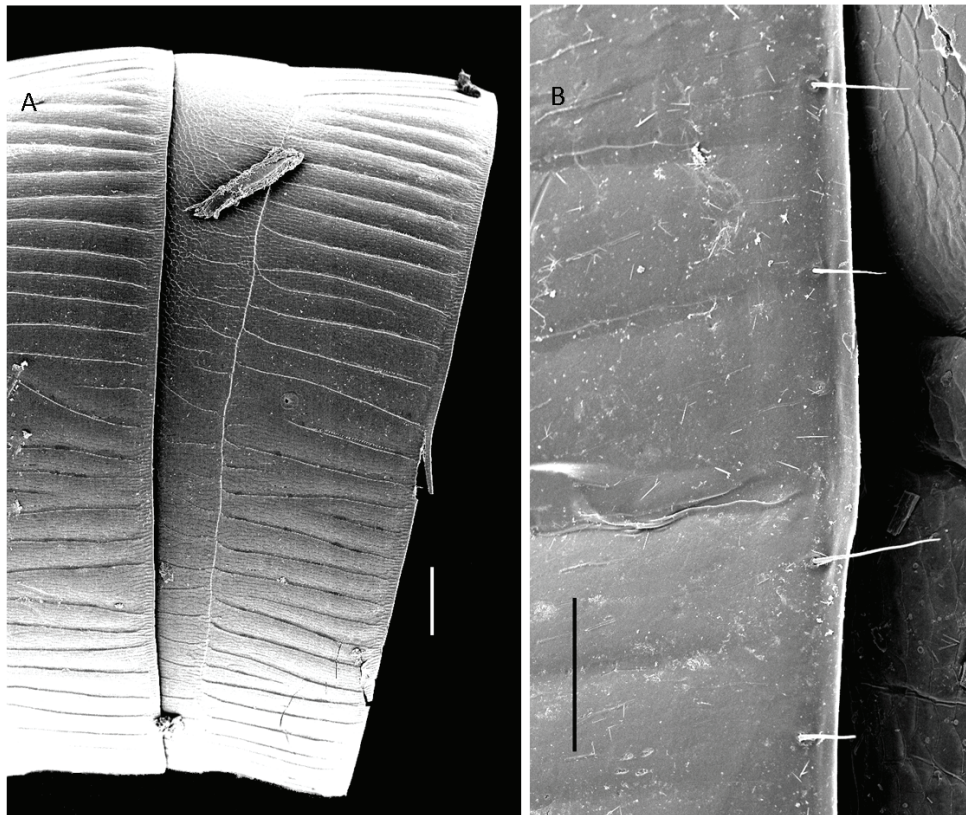


Fig. 2. A. *D. typhlocanaria* sp. nov., male from Cueva de la Luna, midbody rings. Scale 0.1 mm. B. *D. oromii* sp. nov., detail of posterior margin of midbody ring, showing diagnostic setae. Scale 0.05 mm.

COLOUR. The preserved specimens are uniform whitish yellow. Defence glands in part visible by transparency as dark spots.

HEAD. No eyes. 4 supralabral setae. Setae on gnathochilarial stipes: 3 apical, 2-3 (♂) / 0 (♀) nonapical. Length of antennae 156% of H in ♂, 124% of H in ♀.

BODY RINGS. (Fig. 2A) Prozonites posteriorly furrowed, at least in specimens from Cueva de la Luna. Metazonites unvaulted, with *c.* 12 striae per dorsal quarter. Ozopore *c.* 1/3 metazonite length behind suture. Limbus cell length *c.* 4× width; their free margin with a few tiny denticles (as in Enghoff, 1992: figs 28-29).

LEGS. Length 94% of H in ♂, 78% of H in ♀. Claw: length 6-8% of leg, length/height 3.4-5.2. Accessory claw 0.4× shorter than claw.

PREANAL RING. Without a projection, pilosity marginal.

Male

MANDIBULAR STIPITES. Without lobes.

LEGS. Second pair with ventral pads on postfemur and tibia. Postfemoral pads tiny, tibial pads small on midbody legs. Second pair with coxal pores.

ANTERIOR GONOPODS. (Fig. 3A, B) Slender, basal shaft more than half as broad as distal bowl. Ridge with a terminal projection. Lateral prominence distinct. Bowl slender, rounded-triangular. Apical denticles distinct.

POSTERIOR GONOPODS. (Fig. 4A, B) Mesomerital process almost as long as opisthomerite, straight. Opisthomerite slender, straight. Anterior process short, triangular, pointed. Posterior process longer, slender.

Female

RECEPTACULUM SEMINIS. A stalked sphere (as in Enghoff 1992: fig. 48).

Distribution and habitat

Endemic to Gran Canaria. Known from two caves and three MSS in the east-central part of the island.

Dolichoiulus oromii sp. nov.

Figs 2B, 3C, 4C, 5

Diagnosis

A blind species of *Dolichoiulus*. Differs from other blind *Dolichoiulus* species as shown in Table 1. Differs from all other *Dolichoiulus* species, except *D. blancatypa* (Enghoff, 1992) comb. nov., in having metazonital setae. Differs further from the other blind *Dolichoiulus* on Gran Canaria in size (Figs 1, 5), in having extensive preanal pilosity, and in lacking a terminal projection on the mesal ridge of the anterior gonopod. Differs from *D. longunguis* sp. nov. and the widespread *D. typhlops* in having slenderer anterior gonopods (Fig. 3C, cf. Fig. 3D). Differs from *D. blancatypa* (from Tenerife) in having the mesomerital process clearly separated from the opisthomerite.

Etymology

The species is named in honour of Pedro Oromí, La Laguna, Tenerife, in recognition of his vast effort to document and analyse the Canarian fauna.

Table 1. Characteristics of blind *Dolichoilulus* species. Data in part from Enghoff (1992, 2002). Relative lengths of antennae and legs are given in percentage of body diameter. Relative length of claw is given in percentage of total leg length. Diagnostic or near-diagnostic characters shown in **underlined boldface**. There are further subtle gonopod differences between the species.

	body diameter	metazonital setae	preanal projection	subanal projection	preanal pilosity	rel. length of antennae	rel. length of legs	rel. length of claw	anterior gonopods
<i>clioensis</i> (Tenerife)	1.16-1.33 mm (♂)	absent	very short	none	extensive	144% (♂)	87-90% (♂)	5-6%	slender, mesal ridge with projection
<i>ypsilon</i> (Tenerife)	1.07-1.25 mm (♂) 1.22 mm (♀)	absent	long	present	extensive	132-134% (♂) ? (♀)	77% (♂) 70% (♀)	8-9%	slender, mesal ridge with projection
<i>labradæ</i> (Tenerife)	1.12-1.69 mm (♂) 1.18-1.38 mm (♀)	absent	none	none	marginal	179-200% (♂) 163% (♀)	113-119% (♂) 105% (♀)	8-9%	slender, mesal ridge without projection
<i>blancatypa</i> (Tenerife)	0.63-0.87 mm (♂) up to 0.95 mm (♀)	present	none	none	extensive	153% (♂) 104% (♀)	61% (♂) 46% (♀)	11%	stout, mesal ridge without projection
<i>typhlocanaria</i> sp. nov. (Gran Canaria)	1.03-1.26 mm (♂) 1.17-1.41 mm (♀) Fig. XX	absent	none	none	marginal	156% (♂) 124% (♀)	94% (♂) 78% (♀)	6-8%	slender, mesal ridge with projection (Figs 3A, B)
<i>oromii</i> sp. nov. (Gran Canaria)	0.82-1.00 mm (♂) 0.95-1.08 mm (♀) Fig. XX	present	none	none	extensive	162% (♂) 123% (♀)	84% (♂) 74% (♀)	7-8%	slender, mesal ridge without projection (Fig. 3C)
<i>longunguis</i> sp. nov. (Gran Canaria)	0.71 mm (♂) 0.72 mm (♀) Fig. XX	absent	none	none	marginal	138% (♂) 126% (♀)	65% (♂) 61% (♀)	11%	stout (as Fig. 3D), mesal ridge without projection
<i>typhlops</i> (widespread)	0.58-1.25 mm (♂) 0.73-1.42 mm (♀)	absent	short to very short	none	variable	127-168% (♂) 123-130% (♀)	63-93% (♂) 62-77% (♀)	6-10%	stout (Fig. 3D), mesal ridge with projection

Type locality

GRAN CANARIA (Canary Islands), El Sao.

Material studied

all from Canary Islands: Gran Canaria.



Fig. 3. Anterior gonopods, posterior views. **A.** *D. typhlocanaria* sp. nov., specimen from Barranco Draguillo. **B.** *D. typhlocanaria* sp. nov., specimen from Cueva de la Luna. **C.** *D. oromii* sp. nov. **D.** *D. typhlops* Ceuca, 1973, specimen from La Palma, right anterior gonopod. ad: apical denticles, lp: lateral prominence, mr: mesal ridge, p: projection. Scales 0.1 mm (A-C), 0.01 mm (D).

Holotype

♂, El Sao (Agaete), UTM 28R 4354/31049 (28°04'06"N, 15°39'27"W), MSS, 26 Dec. 2005, H. López leg. (DZUL).

Paratypes

3 ♂♂, 2 ♀♀, same data. (2 ♂♂, 2 ♀♀ DZUL, 1 ♂ ZMUC); 1 ♂, same loc., May 2005, H. López leg. (DZUL); 8 ♂♂, 3 ♀♀, 1 juv., same loc., 28 Dec. 2006, H. López leg. (1 ♂ 1 ♀ DZUL, 6 ♂♂ 1 ♀ 1 juv. ZMUC, 1 ♂ 1 ♀ MCNT); 2 ♀♀, same loc., 11 Aug. 2007, H. López leg. (DZUL); 5 ♂♂, 1 ♀, same loc., 7 Jan. 2009, H. López leg. (DZUL); 1 ♂, 1 ♀, same loc., 3 Jan. 2010, H. López leg. (DZUL); 2 ♂♂, same loc., 4 Dec. 2010, H. López leg. (DZUL).

Referred (non-type) material

1 ♀, Caldera de los Marteles, UTM 28R 4481/30920 (27°57'01"N, 15°31'40"W), MSS, 19 Aug. 2006, H. López leg. (MCNT); 1 ♀, same loc., 7 Nov. 2008, H. López leg. (DZUL); 2 ♂♂, 5 ♀♀, same loc., 27 Dec. 2008, H. López leg. (DZUL); 1 ♀, Los Majateles, UTM 28R 4505/30915 (27°56'08"N, 15°30'10"W), MSS, 26 Dec. 2010, H. López leg. (DZUL).

Total material

23 ♂♂, 17 ♀♀, 1 juv. (1 ♂, 1 ♀ analyzed).

Description

♂: L 11-21½ mm, H 0.82-1.00 mm, L/H 13-21, 31-53 podous rings + 1-4 apodous rings in front of telson.
♀: L 14-19 mm, H 0.95-1.08 mm, L/H 15-18, 42-47 podous rings + 1-2 apodous rings in front of telson.

COLOUR. The preserved specimens are uniform whitish yellow. Defence glands in part visible by transparency as dark spots.



Fig. 4. Posterior gonopods, mesal views. **A.** *D. typhlocanaria* sp. nov., specimen from Barranco Draguillo. **B.** *D. typhlocanaria* sp. nov., specimen from Cueva de la Luna. **C.** *D. oromii* sp. nov. ap: anterior process, pp: posterior process, mp: mesomerital process. Scales 0.1 mm.

HEAD. No eyes. 4 supralabral setae. Setae on gnathochilarial stipes: 3 apical, 5 (♂) / 0 (♀) nonapical. Length of antennae 162% of H in ♂, 123% of H in ♀.

BODY RINGS. Prozonites not furrowed. Metazonites unvaulted, with ca. 12 striae per dorsal quarter and a whorl of short setae on the posterior margin (Fig. 2B). Ozopore $\frac{1}{4}$ - $\frac{1}{3}$ metazonite length behind suture. Limbus cells length slightly more than 2× width; their free margin with a few tiny denticles (as in Enghoff 1992: figs 28-29).

LEGS. Length 84% of H in ♂, 74% of H in ♀. Claw: length 7-8% of leg, length/height 4.4-5.4. Accessory claw 0.4-0.5× shorter than claw.

PREANAL RING. Without a projection, pilosity extensive.

Male

MANDIBULAR STIPITES. Without lobes.

LEGS. Second pair with ventral pads on postfemur and tibia. Postfemoral pads tiny, tibial pads small on midbody legs. Second pair with coxal pores.

GONOPODS. (Figs 3C, 4C) As in *D. typhlocanaria* sp. nov., except for the lack of a terminal projection on the mesal ridge of the anterior gonopod.

Female

RECEPTACULUM SEMINIS. A simple sack (as in Enghoff 1992: fig. 47).

Distribution and habitat

Endemic to Gran Canaria. Known only from the type locality in the NW part of the island, and from two further MSS sites in the East-Central part.

Dolichoiulus longunguis sp. nov.

Fig. 5

Diagnosis

A blind species of *Dolichoiulus*. Differs from other blind *Dolichoiulus* species as shown in Table 1. Differs from the other blind *Dolichoiulus* on Gran Canaria in size (Figs 1, 5). Differs from *D. typhlocanaria* sp. nov. and *D. oromii* sp. nov. in having broader anterior gonopods, further from *D. oromii* sp. nov. in lacking metazonital setae and in having only marginal preanal pilosity, and further from *D. typhlocanaria* sp. nov. in lacking a terminal projection on the mesal ridge of the anterior gonopod. Differs from the widespread *D. typhlops* by being slenderer (Fig. 1, cf. Enghoff 2002: fig. 1).

Etymology

The name (noun in apposition) meaning “long claw” and refers to a distinguishing character of this species.

Material studied

Holotype

♂, GRAN CANARIA, Mina Los Roques, UTM 28R 4476/30943 (28°0'0"N, 15°31'56"W), 18 Mar. 2012, M. Naranjo leg. (DZUL).

Paratype

1 ♀, same loc., 23 Jan. 2012, M. Naranjo leg. (DZUL).

Total material

1 ♂, 1 ♀ (analyzed).

Description

♂: L 13 mm, H 0.71 mm, L/H 19, 51 podous rings + 2 apodous rings in front of telson.

♀: L 13 mm, H 0.72 mm, L/H 18, 49 podous rings + 1 apodous ring in front of telson.

COLOUR. The preserved specimens are uniform pale brown.

HEAD. No eyes. 4 supralabral setae. Setae on gnathochilarial stipes: 3 apical, 4 (♂) / 0 (♀) nonapical. Length of antennae 138% of H in ♂, 126% of H in ♀.

BODY RINGS. Prozonites not furrowed. Metazonites unvaulted, striae quite indistinct dorsally (not studied with SEM). Ozopore *c.* 0.4 metazonite length behind suture. Limbus not studied (requires SEM).

LEGS. Length 65% of H in ♂, 61% of H in ♀. Claw: length 11% of leg, length/height 4.5-5.4. Accessory claw 0.3-0.4× shorter than claw.

PREANAL RING. Without a projection, pilosity marginal.

Male

MANDIBULAR STIPITES. Without lobes.

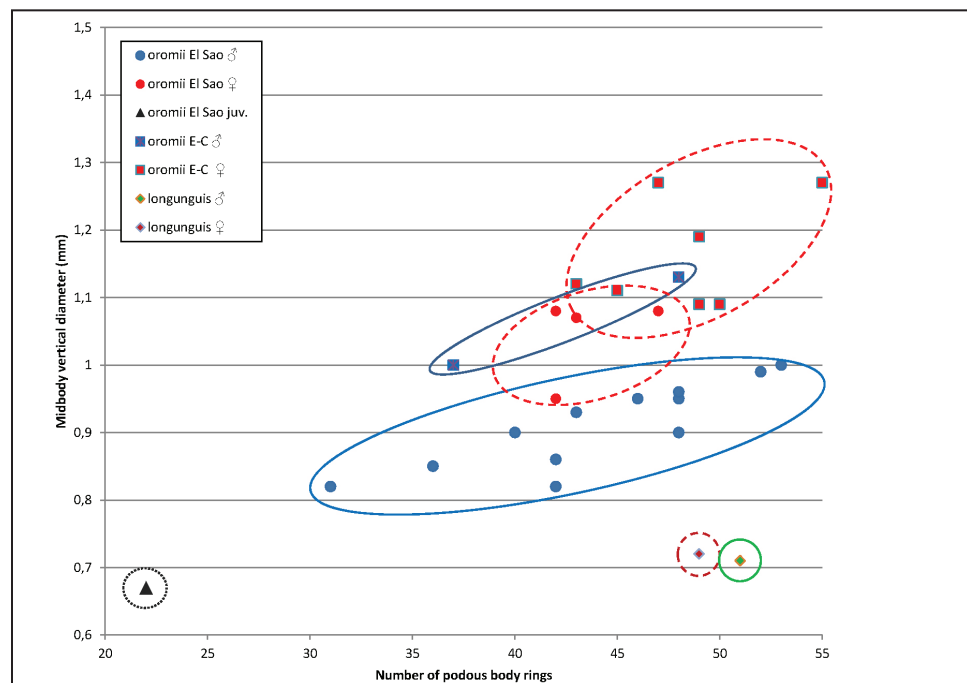


Fig. 5. Size diagram for *Dolichoionulus oromii* sp. nov. and *D. longunguis* sp. nov. The diagram shows number of podous (leg-bearing) body rings (p.r., x axis) and vertical body diameter in mm (y axis). For a given number of podous rings *D. oromii* sp. nov. is thicker than *D. longunguis* sp. nov. but thinner than *D. typhlocanaria* sp. nov. (see Fig. 1); specimens of *D. oromii* sp. nov. from East-Central Gran Canaria are thicker than those from the Northwest (El Sao), and females are thicker than males.

LEGS. Second pair with ventral pads on tibia only. Postfemoral pads absent, tibial pads tiny on midbody legs. Second pair with coxal pores.

ANTERIOR GONOPODS. Indistinguishable from the one shown in Fig. 3D, broader than in *D. typhlocanaria* sp. nov. and *D. oromii* sp. nov. Mesal ridge without a terminal projection. Lateral prominence distinct. Bowl broad, lateral margin regularly convex. Apical denticles distinct.

POSTERIOR GONOPODS. Indistinguishable from those of *D. typhlocanaria* sp. nov. and *D. oromii* sp. nov.

Female

RECEPTACULUM SEMINIS. A stalked sphere (as in Enghoff 1992: fig. 48).

Distribution and habitat

Endemic to Gran Canaria. Known only from the type locality in the east-central part of the island, Collected in an artificial gallery. The short legs and long claws in this species may suggest that it is a soil-digger species rather than a true cave species (*cf.* Enghoff 1982). Among other *Dolichoiulus* species claws as long as those of *D. longunguis* sp. nov. are found only in *D. blancatypa* (Enghoff, 1992) comb. nov. from Tenerife, which also has short legs and is a soil-dweller (Enghoff 1992).

Discussion

It is perhaps not surprising that the first new *Dolichoiulus* species to be found after Enghoff (1992) are from the underground of Gran Canaria. Although caves are scarce on Gran Canaria, there are many deep artificial old galleries such as Mina de los Roques which have produced an interesting subterranean fauna (Naranjo *et al.* 2009). Also, the mesovoid (or mesocavernous) shallow stratum (MSS) is richly represented, and recent collecting activities here have revealed a rich endemic fauna of, e.g., *Lagynochthonius* Beier, 1951 pseudoscorpions, *Symploce* Hebard, 1916 cockroaches and *Oromia* Alonso-Zarazaga, 1987 weevils (Oromí *et al.* 2010; Mahnert, 2011). The abundant artificial caves and MSS spots not yet prospected suggest that the underground of Gran Canaria still has not been exhausted in terms of new millipede species.

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